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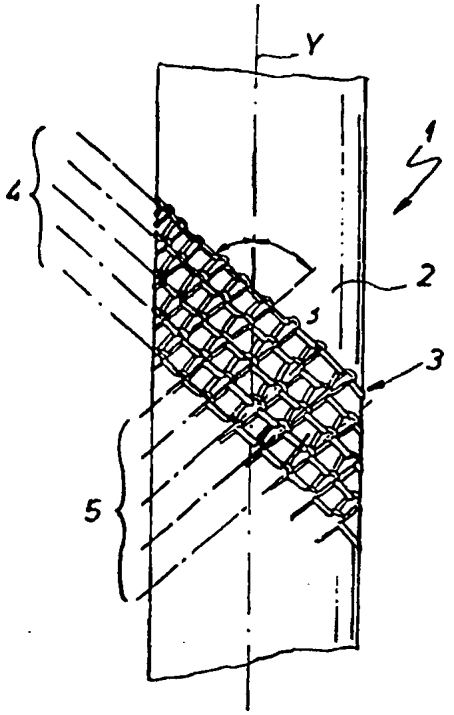
(54) Title: REINFORCED FLEXIBLE HOSE

(57) Abstract

A reinforced flexible hose includes at least one inner tubular layer (2) of plastic or rubber; a knitted reinforcement (3), which has substantially parallel rows (4) and lines (5) of substantially parallel stitches, with respective stitch counts per unit length of the hose (N_m, N_r); and an outer layer (6) which is superimposed on the reinforcement layer (3) to protect it. The knitted reinforcement layer (3) is provided in the form of a single tubular layer and is wrapped around the outer surface of the inner tubular layer (2); the rows (4) and lines (5) of stitches are substantially helical, with respective longitudinal pitches (P_m, P_r) and inclinations which are mutually opposite with respect to the longitudinal axis (Y). The longitudinal pitch (P_r) of the lines (5) of stitches is substantially proportional to the square of the outside diameter (ϕ_o) of the inner layer (2), whilst the number of lines (N_r) of stitches per unit length of the hose is directly proportional to the outside diameter (ϕ_o) of the inner layer (2).



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REINFORCED FLEXIBLE HOSE

The present invention relates to a flexible hose made of plastic or reinforced rubber, with a tubular braiding made of fabric which can be used in the field of irrigation or in the field of the delivery of pressurized fluids in open or closed circuits.

Conventional flexible hoses of the above described type are generally formed by a first tubular inner layer, made of plastic or rubber, on which a tubular fabric is applied for increasing the pressure resistance of the flexible hose, reducing its deformation and increasing its performance.

One of the most widespread and most suitable conventional hose is the so-called "mesh-reinforced" type, in which the tubular reinforcement fabric is constituted by a series of threads spirally wound on the flexible hose in parallel and equidistant rows and superimposed on an equal number of transverse threads along likewise parallel and equidistant lines which are arranged symmetrically with respect to the axis of the hose so as to form a mesh with diamond-shaped cells.

The fabric surrounding the outer surface of the inner layer of plastic is then covered by a further outer layer of plastic or rubber which is generally but not necessarily transparent and fixes the meshed fabric to the flexible hose and protects it. With this type of braiding, the flexible hose is suitable to withstand a higher pressure

than the hose without braiding and to reduce its deformation, because the weaving is of the non-stretch type and therefore prevents the inner layer from deforming.

A drawback of the above described mesh-reinforced hose is the fact that its flexibility is relatively limited; that is to say, the bending radiuses to which the hose can be subjected are rather wide with respect to knit hoses.

Another conventional type of flexible hose is the one in which the braiding that surrounds the outer part of the hose is formed by knitting instead of weaving.

EP-A-0 527 512, in the name of this same Applicant, discloses a hose provided with a particular knit reinforcement in which the individual stitches are shaped like trapezoidal loops with filaments which interweave in the corners. This type of knit reinforcement has the virtue of making the hose stronger than similar knit flexible hoses.

It is known that knitting is a special weaving which is obtained by means of one or more threads which are mutually linked with more or less complex turns, also known as loops or basic stitches, which give the knit fabric great elasticity.

So-called chain knitting is constituted by a series of mutually parallel threads which are fed by multiple spools and are curved so as to form an equal number of lines of

stitches which are interlocked both in the weft direction and in the chain direction; their interweaving produces a transverse series of rows of stitches and a longitudinal series of lines of stitches or cords.

One of the commercially most frequent flexible hoses is the one in which the knitting is of the tricot chain type, where this term describes a stitch in which each thread forms the stitch by interweaving with one or more threads to its right and with one or more threads to its left.

Although, on one hand, the flexible hose with tricot knitting is more flexible, since notoriously the knitting yields as the diameter of the hose increases because of the pressure increase, on the other hand the shortcoming of knitted fabric, and especially of tricot-knitted fabric, is that as the pressure increases, the hose is subjected to a torsional effect by the fluid which flows under pressure inside it. This is due to the helical orientation of the rows of stitches which, by contrast with the substantially longitudinal orientation of the lines, cause an unbalanced reaction, and particularly torque, in the hose.

EP-A-0 623 776 in the name of this same Applicant discloses a hose which includes, from the inside outward: an inner layer of plastic or rubber which has an outer surface; a chain-knit part, which has rows and lines of stitches, and has a tubular shape and is wound in a single layer around the outer surface of the inner layer; and an outer stitch protection layer; wherein the lines and rows of stitches

are inclined in opposite directions with substantially the same inclination with respect to the longitudinal axis of the hose in order to eliminate the effects of the torque produced by the pressure loads inside the hose.

This prior patent provides no correlation among the various parameters of the knit reinforcement part, such as the pitch, the inclination and the thread count per unit length, neither among them or with respect to the dimensional parameters of the inner layer. Accordingly, due to the large number of parameters involved and to their large number of possible combinations, the person skilled in the art does not have all the information required to assuredly achieve the intended results or at least optimize the anti-torque effect of the hose.

An aim of the present invention is to eliminate the above described drawbacks.

A further aim of the invention is to provide a correlation between the various parameters of the braiding and those of the inner layer, such as to eliminate the torque produced on the knitted fabric by the pressure of the fluid, without thereby renouncing flexibility and bursting pressure resistance characteristics.

This aim and other objects which will become apparent hereinafter are achieved by a flexible hose according to the invention, which in accordance with the content of the first claim includes: at least one inner tubular layer of

plastic or rubber which has an outside diameter and a longitudinal axis; a knitted reinforcement of the chain type, which has rows of substantially parallel stitches and lines of substantially parallel stitches with respective stitch counts per unit length in a longitudinal direction, the knitted reinforcement layer being provided in the form of a single tubular layer and being wrapped around the outer surface of the inner tubular layer coaxially thereto, the rows and lines of stitches being substantially helical with respective longitudinal pitches and inclinations which are mutually opposite with respect to the longitudinal axis, so as to eliminate the torque applied by the pressure of the fluid inside it; and an outer layer which is superimposed on the reinforcement layer to protect it; characterized in that the longitudinal pitch of the lines of stitches is substantially proportional to the square of the outside diameter of the inner layer.

Surprisingly, it has been found that in order to eliminate the torque induced by the internal pressure of the fluid, the pitch of the lines of stitches must increase as the inner diameter but not according to a linear relation but rather according to a quadratic relation, in order to effectively contrast the rotation induced by the uncoiling of the helical threads of the stitches.

At the same time, the longitudinal pitch of the rows of stitches can be kept substantially constant and independent of the outside diameter of the inner layer.

Preferably, the number of lines of stitches per unit length of the hose is directly proportional to the outside diameter of the inner layer.

Further characteristics and advantages of the present invention will become apparent from the following description of a preferred embodiment of the invention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a view of a portion of the flexible hose according to the invention;

Figure 2 is a sectional view of the hose of Figure 1;

Figure 3 is a diagram showing the main parameters of the chain knitting of the reinforcement braiding according to the invention with respect to the outside diameter of the inner layer.

With reference to the above figures, the flexible hose according to the invention, generally designated by the reference numeral 1, is formed by an inner layer 2 made of polymeric or elastomeric material such as PVC, natural or synthetic rubber, which is essentially tubular and has a longitudinal axis Y which coincides with the axis of the flexible hose, an inner surface which has an inside diameter ϕ_i, and an outer surface which has a diameter ϕ_o.

A chain-knitted part, generally designated by the reference

numeral 3, is knitted on the inner layer 2 and is formed by substantially helical rows 4 of stitches, which are mutually parallel and have an inclination angle α with respect to the axis Y of the hose 10 of Figure 2, and by lines 5 which are also substantially helical and have an inclination angle ß with respect to the axis Y, but in the opposite direction with respect to the rows 4.

The rows and lines have respective longitudinal pitches P_m and P_r. Furthermore, the linear count or number of lines per unit length (100 mm) of the rows or stitches is respectively N_m and N_r.

It is known that if the outside diameter ϕ_o of the inner layer 2 on which the braiding 3 is wound increases, it is necessary to increase the pitch of the lines in order to be able to contain the torque. However, until now a precise correlation between these parameters had not been established. Surprisingly, tests and experiments have allowed to verify that the relation between these parameters is not linear but is instead quadratic.

In other words, this relation can be expressed by the general formula:

$$P_r = K \phi^2 \qquad (1)$$

where the parameter K depends on the materials and units of measure used.

In the case of PVC and if all parameters are expressed in mm, the constant K of formula (1) is generally between 0.35 and 0.50 mm^{-1} and is preferably equal to approximately 0.45 mm^{-1}.

It is noted that the knitted reinforcement of the hose of Figure 1 is formed by chain stitches of the tricot type. These stitches are formed directly on the hose by so-called knitting machines which are commercially available and whose stitch-forming method is well-known.

With this crossed and inclined arrangement with respect to the axis Y of the hose, the torque which occurs on the hose in case of normal chain stitches, for example with substantially longitudinal lines, is canceled out. On the contrary, by arranging the lines transversely instead of longitudinally the rotary force component which appeared due to the coiling of the spiral-shaped rows 5 is compensated.

With this type of knitting, the forces produced by the lines and rows of stitches mutually compensate until they cancel each other out, thus making the hose 1 substantially insensitive to the torque induced by the pressure of the fluid inside the hose.

It is noted instead that the longitudinal pitch P_m of the rows of stitches can be kept substantially constant and independent of the outside diameter ϕ_o of the inner layer.

Furthermore, the number N_r of lines of stitches per unit length of the hose is substantially directly proportional to the outside diameter ϕ_o.

The angles α and ß are generally mutually different, but their sum is approximately constant and equal to, or slightly smaller than, 90° as the value of the outside diameter ϕ_o of the inner layer 2 varies.

In particular, it has been observed that the inclination angle ß of the lines of stitches 5 is substantially proportional to the square root of the outside diameter ϕ_o of the inner layer 2.

When using values between 12 and 37 mm for the outside diameter ϕ_o and between 10 and 32 mm for the inside diameter ϕ_i, it has been observed that the number of rows per unit length N_m is substantially constant and is between 30 and 40 rows per 100 mm, with an average value of 35 rows per 100 mm.

In the same conditions, the number of lines per unit length N_r is substantially proportional to the outside diameter ϕ_o of the inner layer 2 and is between 10 and 16 rows per 100 mm.

The above parameters are summarized in Table I below and most of them have been plotted in the chart of Figure 3.

TABLE I

Outside diameter of inner layer Ø o (mm)	Inside diameter of inner layer Ø i (mm)	Pitch of rows Pr (mm)	Pitch of lines Pm (mm)	Inclination angle of lines (°)	Inclination angle of rows (°)	No. of lines per unit length Nr (n/100mm)	No. of rows per unit length Nm (n/100mm)
12.5	10	70	22.7	60	30	10	35
15	12.5	100	22.7	64	26	10/12	35
18	15	140	22.7	68	22	12	35
22.5	19	220	22.7	72	18	12	35
29.5	25	380	22.7	76	14	16	35
37	32	600	22.7	79	11	16	35

Finally, an outer layer 6 made of plastic or rubber locks the chain knitting thus formed on the surface of the hose, as occurs besides in all known flexible hose structures.

It is important to note that the inclination of the lines and rows of stitches can be slightly modified with respect to the above indicated values according to the material of the hose, its diameter, the type of knitting, the number of spools, the pitch of the rows and lines, and the type and/or count of the thread.

CLAIMS

1. Reinforced flexible hose, comprising:

at least one inner tubular layer (2) of plastic or rubber which has an outside (ϕ_e) diameter and a longitudinal axis (Y);

a chain knitted-type reinforcement layer (3), which has rows (4) of substantially parallel stitches and lines (5) of substantially parallel stitches, with respective stitch counts per unit length (N_m, N_r) in a longitudinal direction;

said knitted reinforcement layer (3) being provided in the form of a single tubular layer and being formed on the outer surface of said inner tubular layer (2) coaxially thereto;

said rows (4) of stitches and said lines (5) of stitches being substantially helical with respective longitudinal pitches (P_m, P_r) and inclinations (α, β) which are mutually opposite with respect to the longitudinal axis (Y), so as to eliminate the torque applied by the pressure of the fluid inside it; and

an outer layer (6) which is superimposed on said reinforcement layer (3) to protect it;

characterized in that the longitudinal pitch (P_r) of said lines (5) of stitches is substantially proportional to the

square of the outside diameter (ϕ_o) of said inner layer (2).

2. Flexible hose according to claim 1, characterized in that the number of lines of stitches per unit length (N_r) is substantially directly proportional to the outside diameter (ϕ_o) of said inner layer (2).

3. Flexible hose according to claim 1, characterized in that the longitudinal pitch (P_m) of the rows of stitches is substantially constant and independent of the outside diameter (ϕ_o) of said inner layer (2).

4. Flexible hose according to claim 1, characterized in that said rows (4) and said lines (5) of substantially helical stitches have different inclination angles (α, β) whose sum is substantially constant and equal to, or slightly lower than, 90° as the value of the outside diameter (ϕ_o) of said inner layer (2) varies.

5. Flexible hose according to claim 4, characterized in that the angle of inclination (β) of the lines (5) of stitches is substantially proportional to the square root of the outside diameter (ϕ_o) of said inner layer (2).

6. Flexible hose according to claim 1, characterized in that in said inner layer (2) the outside diameter (ϕ_o) is between 12 and 27 mm and the inside diameter (ϕ_i) is between 10 and 32 mm.

7. Flexible hose according to claim 1, characterized in that the number of rows per unit length (N_m) is substantially constant as the outside diameter (ϕ_o) of said inner layer (2) varies, and is between 30 and 40 rows per 100 mm, with an average number of 35 rows per 100 mm.

8. Flexible hose according to claim 1, characterized in that the number of lines per unit length (N_r) is substantially proportional to the outside diameter (ϕ_o) of said inner layer (2) and is between 10 and 16 lines per 100 mm.

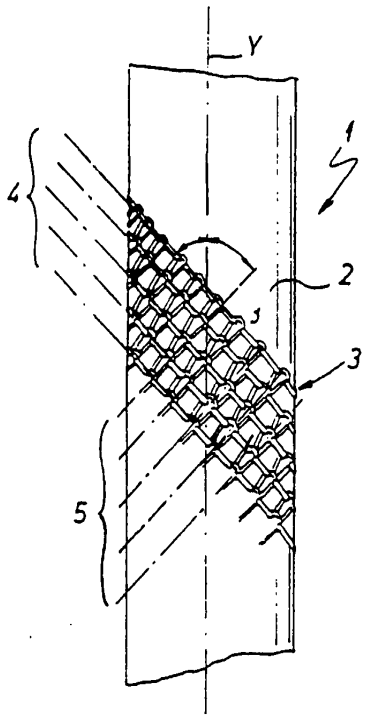

FIG. 1

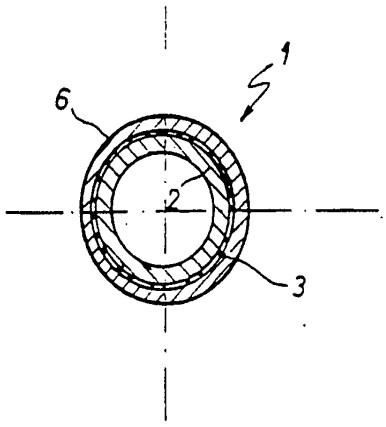

FIG. 2

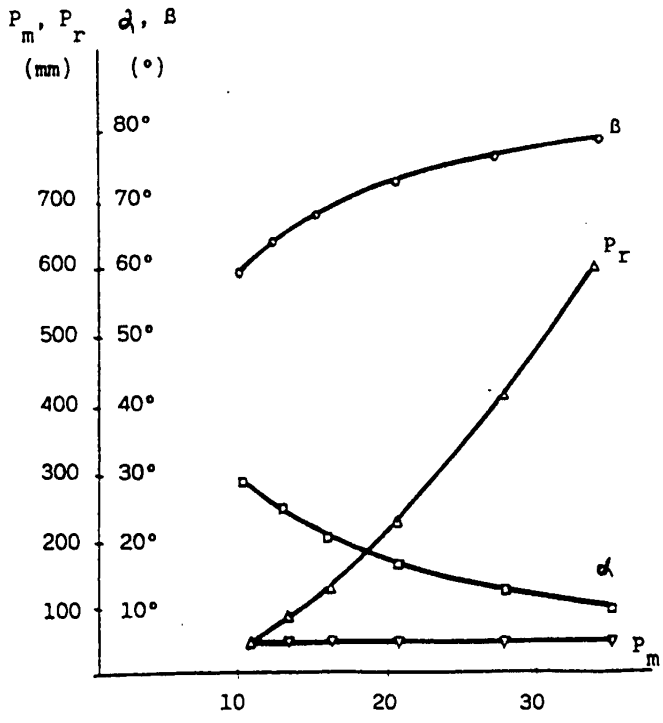

FIG. 3

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PATENT COOPERATION TREATY

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NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

WAGNER, Karl, H.
Wagner & Geyer
Gewuerzmuehlstr. 5
D-80538 Munich
ALLEMAGNE

Date of mailing (day/month/year)
04 June 1998 (04.06.98)

Applicant's or agent's file reference
44001 RMT/vg

IMPORTANT NOTIFICATION

International application No.
PCT/EP97/02155

International filing date (day/month/year)
25 April 1997 (25.04.97)

1. The following indications appeared on record concerning:

[ ] the applicant [ ] the inventor [X] the agent [ ] the common representative

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State of Residence:
Telephone No.:
Facsimile No.:
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [ ] the name [X] the address [ ] the nationality [ ] the residence

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Teleprinter No.:

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

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[ ] the International Preliminary Examining Authority
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[X] other: FORATTINI, Amelia

The International Bureau of WIPO
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1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer
Nicola Wolff

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

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NOTIFICATION OF ELECTION

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Date of mailing (day/month/year) 11 September 1998 (11.09.98)	
International application No. PCT/EP97/02155	**Applicant's or agent's file reference** 44001 RMT/vg
International filing date (day/month/year) 25 April 1997 (25.04.97)	**Priority date** (day/month/year) 20 February 1997 (20.02.97)
Applicant MEZZALIRA, Rinaldo	

1. The designated Office is hereby notified of its election made:

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   26 August 1998 (26.08.98)

   [ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

   [ ] was not

   made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

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Authorized officer

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COMMUNICATION OF
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(PCT Article 20)

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in its capacity as designated Office

Date of mailing:
24 December 1997 (24.12.97)

The International Bureau transmits herewith copies of the international applications having the following international application numbers and international publication numbers:

International application no.:	International publication no.:
PCT/EP97/02155	WO97/41719

CORRECTED VERSION
VERSION CORRIGEE

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Facsimile No.: (41-22) 740.14.35

Authorized officer:

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PATENT COOPERATION TREATY

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
44001 RMT/vg		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/EP 97/02155	25/04/1997	20/02/1997
Applicant		
FITT S.P.A. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (see Box I).

2. [ ] **Unity of invention is lacking** (see Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
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   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] Transcribed by this Authority

4. With regard to the **title,**
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   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this International Search Report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is:

   Figure No. 1
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 97/02155

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16L11/08 D04B9/44

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F16L D04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 726 416 A (THE GOODYEAR TIRE & RUBBER COMPANY) 14 August 1996 see the whole document ---	1
A	US 3 921 674 A (LOGAN ET AL.) 25 November 1975 see the whole document ---	1
A	DE 34 08 251 A (PHOENIX AG) 12 September 1985 see the whole document ---	1
A	EP 0 623 776 A (FITT S.P.A.) 9 November 1994 cited in the application see the whole document --- -/--	1

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
14 October 1997	12. 11. 97

Name and mailing address of the ISA	Authorized officer
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Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 044 799 A (C. D. HIGBEE ET AL.) 30 August 1977 see the whole document -----	1

INTERNATIONAL SEARCH REPORT

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International Application No
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INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/NL 98/00112

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E03F5/20 F16L43/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E03F F16L E03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 35 01 693 A (LIEBERZ) 24 July 1986 see page 3, line 19 - line 21; claim 3; figures	1,2,5-7
A	DE 89 02 878 U (NILL) 3 May 1989 see page 5, line 14 - line 27	1,2,5-7
A	EP 0 011 778 A (AB GUSTAVSBERG) 11 June 1980 cited in the application see abstract	1
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☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
28 May 1998	08/06/1998

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